# PROPOSED U. S. QUANTITY-DISTANCE RULES FOR HAZARD DIVISION 1.2 AMMUNITION

by

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## ABSTRACT

An extensive Hazard Division (HD) 1.2 open-air testing program has been completed and is being reported on separately at this seminar. The results of both this program and a literature survey form the basis of a data base of HD 1.2 effects. Currently, for quantity-distance purposes, HD 1.2 ammunition is treated differently than HD 1.1 items. The data base of HD 1.2 effects suggests that this difference is not appropriate. Based on this data base, proposed changes to the US quantity-distance criteria for HD 1.2 ammunition have been developed. This paper will describe those proposed changes. It will then compare the proposed change to the US criteria with both the current US and NATO/UK criteria.

## INTRODUCTION

Interim or status reports on the US/UK Hazard Division (HD) 1.2 testing program were previously presented at both the United States and Australian Safety Seminars[1-4]. Since then, additional testing has been completed both in the United States and in Germany. The US/UK testing program is described in a separate paper that is being presented at this seminar. The results of these testing programs have been used to revise the description of the accepted behavior of HD 1.2 items. These results also form the basis for proposed changes to the appropriate explosives safety standards. The subsequent sections of this paper will discuss these topics in more detail.

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## THE US/UK TESTING PROGRAM

The testing portion of the US/UK-sponsored HD 1.2 open-air testing program has been concluded. During this effort, fourteen tests have been completed and analyzed. These are shown in Table 1.

### TABLE 1. US/UK HD 1.2 TESTING PROGRAM IN OPEN AIR

| TEST IDENTIFIER | NUMBER OF PALLETS | BOXES PER PALLET | NUMBER OF ROUNDS | TEST DATE | TEST ITEM | TYPE OF BOX | TYPE OF TEST |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 15 | 30 | 7-May-91 | 105 mm/TNT | Wood | External Fire |
| 2 | 1 | 15 | 30 | 24-Jun-91 | 105 mm/TNT | Wood | External Fire |
| 3 | 1 | 15 | 30 | 29-Jul-91 | 105 mm/TNT | Wood | External Fire |
| 4 | 8 | 15 | 240 | 29-Oct-91 | 105 mm/TNT | Wood | External Fire |
| 5 | 8 | 15 | 240 | 29-Apr-92 | 105 mm/TNT | Wood | External Fire |
| 6 | 27 | 16 | 864 | 28-Oct-92 | 105 mm/TNT | Wood | External Fire |
| 7 | 3 | 16 | 96 | 3-May-94 | 105 mm/COMP B* | Wood | External Fire |
| 8 | 2 | 30 | 180 | 15-Sep-94 | 81 mm/COMP B | Wood | External Fire |
| 8A | | | 12 | 8-Sep-94 | 81 mm/COMP B | Metal | External Fire** |
| 9 | 2 | 30 | 180 | 11-May-95 | 81 mm/COMP B | Metal | External Fire |
| 10 | 4 | 16 | 128 | 17-May-95 | 105 mm/COMP B | Wood | External Fire |
| 11A | | | 15 | 20-Sep-95 | 81 mm/Comp B | Metal | Stack** |
| 11B | | | 15 | 20-Sep-95 | 81 mm/Comp B | Metal | External Fire** |
| 12 | 8 | 30 | 720 | 26-Sep-95 | 81 mm/COMP B | Metal | External Fire |

* tested without nose plugs
**pseudo-hazard classification tests

The US/UK program has used three separate rounds. These are: (1) 105 mm, TNT-loaded cartridge, (2) 105-mm, Composition B-loaded cartridge, and (3) 81 mm, Composition B-loaded cartridge.

The M1 105 mm cartridge is a semi-fixed high explosive artillery round. The projectile body is fabricated from forged steel and weighs approximately 25.8 pounds (11.7 kg). An aluminum shipping plug is assembled into the nose of the projectile in lieu of a fuze. The propelling charge consists of approximately 3 pounds (1.4 kg) of M1 propellant contained in a spiral wrap steel case. Each propelling charge case weighs approximately 4.7 pounds (2.1 kg). Several variants of the M1 cartridge have been produced with projectiles that contain either TNT or Composition B explosive. Each round contains approximately 4.5 pounds (2.0 kg) of high explosive. The item is packaged two to a wooden box. A pallet consists of either 15 or 16

wooden boxes. The item is currently hazard classified in the United States as (12)1.2E; i.e., its maximum fragment range is 1200 feet (366 m) based on the original hazard classification testing.

The items tested were taken from ammunition with the following DODIC/NSN/NALC (Department of Defense Information Code/National Stock Number/Naval Ammunition Logistics Code):

**TABLE 2. M1 105 mm ROUNDS TESTED**

| TNT | COMPOSITION B |
|---|---|
| C445 1315-00-145-7554 | C445 1315-00-028-4857 |
| C445 1315-00-146-6853 | C445 1315-00-028-4860 |
| C445 1315-00-215-8884 | C445 1315-00-231-4629 |
| | C445 1315-00-926-4081 |

The M374A2 is an unfuzed, 81 mm mortar cartridge. The complete round consists of a projectile body, a fin assembly that includes a cartridge housing, a propellant charge with two types of increment charges, and an ignition charge. Each round contains 2.1 pounds (0.95 kg) of Composition B explosive and 0.33 pounds (0.15 kg) of M1 propellant. The item is packaged one per container, three containers per wooden box. A pallet consists of 30 boxes. The round is currently hazard classified in the United States as (08)1.2E; i.e., its maximum fragment range is 800 feet (244 m) based on the original hazard classification testing. The items tested were taken from ammunition with the following DODIC/NSN/NALC:

C236 1315-00-935-6007
C236 1315-00-935-6013

The 81-mm mortar rounds used on Tests 8 and 10 were in their standard packaging. This consisted of each round packaged in a fiberboard tube, with three such tubes inside each wooden box. The wooden boxes were formed into pallets with 30 boxes on each pallet. To investigate the effects of the packaging on the observed HD 1.2 behavior, rounds were repackaged for several tests (Tests 8A, 9, 11A, 11B, and 12). Rounds were removed from their regular packaging. Each round was placed inside a plastic handling tube. These plastic tubes were then placed in metal boxes (three rounds to a box). On Tests 9 and 12, the metal boxes were stacked into pallet configurations. These pallets had the same approximate dimensions as those containing wooden boxes and contained the same numbers of rounds. The test configurations for Tests 8A, 11A, and 11B were similar to those used for hazard classification purposes. These tests were performed to insure that the change in packaging does not result in an apparent change in the hazard classification to HD 1.1.

## OTHER DATA

Beyond the data collected by this program, related information has been obtained from the published literature and from other test reports describing recent work. This information includes Japanese work on 105 mm projectiles[5], and Norwegian[6], US[7], and German[8] work on 40 mm projectiles.

The Japanese paper describes bonfire tests conducted on TNT-loaded, 105 mm projectiles inside a tunnel--simulating underground storage. These results confirmed the type of behavior observed on the US/UK open-air tests. There was a delay of at least 15-20 minutes after the start of the fire before the first event occurred. After that first event, the rounds reacted sequentially "popcorn-fashion."

The Norwegian 40 mm data were obtained as part of an investigation of a shipping accident. The data obtained from this study were used to calculate fragment density versus range information for this round. These test data indicated that this round had a maximum fragment range of approximately 500 feet (152 m).

About fifteen years ago, as part of the Fragment Hazard Investigation Program, the Department of Defense Explosives Safety Board (DDESB) sponsored a series of large bonfire tests of 40 mm antiaircraft rounds. This series of tests culminated in an event involving over 6000 rounds of 40 mm ammunition. Because of the large number of rounds involved, the statistics of the recovery process meant that the maximum fragment range should be well defined; i.e., because of the large numbers of rounds involved, the probability of recovering a fragment near the true maximum range should be high. A recent, detailed examination of both how the test was conducted and the data obtained indicates that there may be problems with this data set. The exact nature of the rounds tested cannot be determined; i.e., neither the type of round (description and DODIC/NSN/NALC) nor weight of either the explosive or propellant was available. Further, the test site had been previously used for other testing and the fragment recovery operations were not under the direct supervision of project personnel. Thus, items from previous tests could have been attributed to the 40-mm test results. Because of these questions, the authors have chosen not to give this data set as much credibility as the other data described in this section.

Under the auspices of NATO AC/258, Germany is currently acquiring data on three of their 40 mm rounds. Thus far, two external fire tests have been conducted with full fragment recovery. Preliminary data from these tests have been made available and the results have been added to the data base.

Other tests are in various stages of preparation. France is currently planning a series of external fire tests using HD 1.2 rocket motors (R530 missiles without warheads). The UK and Australia are planning to conduct a bonfire test inside a SPANTECH igloo filled with 105 mm projectiles. This test is a follow-up to smaller scale one and eight pallet tests in the same igloo. The US is analyzing the results of bonfire tests conducted inside a miniature magazine. As these data become available, they will be included in the data base and compared with the remaining data.

## CURRENT RULES

The current NATO and UK QD prescriptions are defined in Allied Ammunition Storage and Transport Publication (AASTP-1) for NATO and ESTC leaflet 5 Part 2 for the UK. Under this system, there is a broad division, based loosely on calibre, into:

(i) those items which give small fragments of moderate range (calibre < 60 mm): $D=53Q^{0.18}$ (D in meters, Q is Net Explosive Quantity (NEQ) in kilograms) with a minimum of 180 meters and a maximum of 410 m.

(ii) those items which give large fragments with considerable range (calibre > 60 mm): $D=62Q^{0.18}$ (D in meters, Q is Net Explosive Quantity (NEQ) in kilograms) with a minimum of 270 meters and a maximum of 560 m.

NOTE: The 60 mm division is considered somewhat arbitrary; however, it is purported to be based on test data that is either not currently available or cannot be found.

US quantity-distance regulations are defined in the Department of Defense Ammunition and Explosives Safety Standards[9]. Currently, for HD 1.2 items, safety distances are related to the maximum range of hazardous projections as determined by hazard classification tests that are performed for that specific ammunition item.

The NATO and UK criteria differ in principle from the current US criteria. The US criteria are round specific and quantity independent whereas the NATO/UK criteria are round generic and quantity dependent. There is one other major difference between the US and the NATO/UK approaches. That involves the calculation of the NEQ or NEW. In the US, the weight of any HD 1.3 material is considered part of the total NEW. Under the NATO/UK approach, only those explosives shown to contribute to the explosion effects need to be considered, although, in practice, the total NEQ of the article is taken as no reliable data exists to do otherwise.

## PROPOSED APPROACH FOR QUANTITY-DISTANCE RULE CHANGES IN THE UNITED STATES

Based on the data that has been obtained and/or analyzed during this program, an approach similar to that taken by NATO and the UK seems appropriate. Namely, a quantity-distance (QD) range that is dependent upon a combination of: (1) the Net Explosive Weight (NEW) of a single round and (2) the total HD 1.1 weight of all the items in the stack. This would obviate the requirement for a fragment recovery test for every new weapon system. The NEW or NEQ for a single round is the weight of the HD 1.1 material plus the weight of any HD 1.3 material known to contribute to the event. Based on the data that have been obtained to date, for the purposes of quantity-distance determination, it is assumed that the HD 1.3 material does not contribute unless there is evidence otherwise. In some situations, there may only be HD 1.3 materials and no HD 1.1 materials present. Examples of these might include certain rocket motors or kinetic energy penetration rounds. In these situations, the HD 1.3 weight should be used as the basis for quantity-distance calculations.

The approach described herein represents the current thinking of the authors. It has evolved over the last two years and is significantly different from the material presented at the Australian Safety Seminar in October 1995[2]. This material has not been fully staffed and does not represent an official position. Further, since related testing is still underway, these ideas should be taken as generic and evolving, rather than representing an absolute answer.

The following definitions are required for this section. The Net Explosive Weight (NEW) of an item is the sum of the weight of the HD 1.1 and 1.3 material contained in an item. The Net Explosive Weight for QD (NEW/QD) for an item includes a 100% contribution of the HD 1.1 material and any known or documented contribution of the HD 1.3 materials. The Quantity-Distance Weight (QDW) is equal to the number of items multiplied by the NEW/QD for a single item. The Maximum Credible Event (MCE) is the total weight of the HD 1.1 and 1.3 material that would be involved in the worst single event that is likely to occur.

The effects produced by the functioning of HD 1.2 items will vary with the size and weight of the item. HD 1.2 ammunition can be segregated into two categories to account for the differences in magnitude of these effects for purposes of setting quantity-distance criteria for storage. The least hazardous items, called Category 1 items, have an NEW/QD less than or equal to 0.30 lbs (0.135 kg). The more hazardous items are called Category 2 items and have an NEW/QD greater than or equal to 0.30 pounds. These two categories are shown below with their definitions:

| | |
|---|---|
| CATEGORY 1: | NEW/QD $<$ 0.30 lbs |
| CATEGORY 2: | NEW/QD $\geq$ 0.30 lbs |

The breakpoint between the two categories is based on all of the test data that is currently available. Category 1 uses a combination of the Norwegian and German 40 mm data. Category 2 is based on a combination of the 81 mm mortar and 105 mm cartridge data. Within each Category, a curve fit of the type:

$$IBD = A + B*(\ln(QDW)) + C*(\ln(QDW))^2$$

was made to the maxima of the data. For Category 1, the Norwegian data was dominant for low values of QDW, while the German data controlled the fit at large values of QDW. For Category 2, the 81 mm data controlled the results except at large values of QDW. These equations are shown in the Notes at the bottoms of Tables 3 and 4.

Tables 3 and 4 show the proposed inhabited building distances (IBD), public traffic route distances (PTR), and intraline distances (ILD) for the two Categories of HD 1.2 ammunition. Intermagazine distances (IMD) are dependent upon the types of structures acting as both the Potential Explosion Site (PES) and the Exposed Site (ES). Table 5 provides the appropriate IMD separations for various combinations of ES and PES.

PTR distances which are also shown in Tables 3 and 4 give consideration to the transient nature of the exposure in the same manner as for HD 1.1. PTR distance is computed as 60% of the IBD for items in this hazard division.

**TABLE 3. PROPOSED HD 1.2 QUANTITY-DISTANCES (IBD, PTR, ILD) FOR CATEGORY 1 (NEW/QD < 0.30 lbs)**

| QDW (lbs) | IBD[1,2] (ft) | PTR[3] (ft) | ILD[4] (ft) | QDW (lbs) | IBD[1,2] (ft) | PTR[3] (ft) | ILD[4] (ft) |
|---|---|---|---|---|---|---|---|
| 1 | 328 | 197 | 164 | 7,000 | 434 | 260 | 217 |
| 2 | 328 | 197 | 164 | 8,000 | 438 | 263 | 219 |
| 5 | 328 | 197 | 164 | 9,000 | 441 | 264 | 220 |
| 10 | 328 | 197 | 164 | 10,000 | 444 | 266 | 222 |
| 20 | 328 | 197 | 164 | 15,000 | 454 | 272 | 227 |
| 40 | 328 | 197 | 164 | 20,000 | 460 | 276 | 230 |
| 60 | 328 | 197 | 164 | 25,000 | 466 | 279 | 233 |
| 80 | 328 | 197 | 164 | 30,000 | 469 | 282 | 235 |
| 100 | 328 | 197 | 164 | 40,000 | 475 | 285 | 238 |
| 150 | 328 | 197 | 164 | 50,000 | 480 | 288 | 240 |
| 200 | 328 | 197 | 164 | 60,000 | 483 | 290 | 242 |
| 300 | 328 | 197 | 164 | 70,000 | 486 | 292 | 243 |
| 400 | 338 | 203 | 202[5] | 80,000 | 488 | 293 | 244 |
| 600 | 354 | 212 | 228[5] | 90,000 | 490 | 294 | 245 |
| 800 | 364 | 219 | 247[5] | 100,000 | 492 | 295 | 246 |
| 1,000 | 373 | 224 | 261[5] | 150,000 | 498 | 299 | 249 |
| 1,500 | 387 | 232 | 287[5] | 200,000 | 502 | 301 | 251 |
| 2,000 | 396 | 238 | 304[5] | 250,000 | 505 | 303 | 253 |
| 2,500 | 403 | 242 | 318[5] | 300,000 | 507 | 304 | 254 |
| 3,000 | 409 | 246 | 329[5] | 350,000 | 509 | 305 | 254 |
| 3,500 | 414 | 248 | 338[5] | 400,000 | 510 | 306 | 255 |
| 4,000 | 418 | 251 | 346[5] | 450,000 | 512 | 307 | 256 |
| 5,000 | 425 | 255 | 360[5] | 500,000 | 513 | 308 | 256 |
| 6,000 | 430 | 258 | 215 | >500,000 | 520 | 312 | 260 |

NOTES:

(1) $IBD = 24.7 + 65.0*(\ln(QDW))-2.12*(\ln(QDW))^2$
QDW in pounds, IBD in feet with a 328 feet minimum distance

(2) Use of equation to determine IBD ranges for other weights is allowed

(3) PTR = 60% of IBD

(4) ILD = 50% of IBD

(5) If the QDW of Category 1 HD 1.2 items at an operating line PES is limited to 5,000 pounds, then ILD may be reduced to 200 feet

## TABLE 4. PROPOSED HD 1.2 QUANTITY-DISTANCES (IBD, PTR, ILD) FOR CATEGORY 2 (NEW/QD $\geq$ 0.30 lbs)

| QDW (lbs) | IBD[1,2] (ft) | PTR[3] (ft) | ILD[4] (ft) | QDW (lbs) | IBD[1,2] (ft) | PTR[3] (ft) | ILD[4] (ft) |
|---|---|---|---|---|---|---|---|
| 1 | 656 | 394 | 328 | 7,000 | 1317 | 790 | 659 |
| 2 | 656 | 394 | 328 | 8,000 | 1341 | 805 | 670 |
| 5 | 656 | 394 | 328 | 9,000 | 1362 | 817 | 681 |
| 10 | 656 | 394 | 328 | 10,000 | 1380 | 828 | 690 |
| 20 | 656 | 394 | 328 | 15,000 | 1449 | 870 | 725 |
| 40 | 656 | 394 | 328 | 20,000 | 1497 | 898 | 749 |
| 60 | 656 | 394 | 328 | 25,000 | 1534 | 920 | 767 |
| 80 | 656 | 394 | 328 | 30,000 | 1564 | 938 | 782 |
| 100 | 1250, 656[5] | 750, 394[5] | 625, 233[5] | 40,000 | 1609 | 966 | 805 |
| 150 | 1250, 656[5] | 750, 394[5] | 625, 278[5] | 50,000 | 1644 | 987 | 822 |
| 200 | 1250, 656[5] | 750, 394[5] | 625, 309[5] | 60,000 | 1673 | 1004 | 836 |
| 300 | 1250, 706[5] | 750, 423[5] | 6253535 | 70,000 | 1696 | 1018 | 848 |
| 400 | 1250, 766[5] | 750, 460[5] | 625, 383[5] | 80,000 | 1716 | 1030 | 858 |
| 600 | 1250, 849[5] | 750, 510[5] | 625, 425[5] | 90,000 | 1734 | 1040 | 867 |
| 800 | 1250, 908[5] | 750, 545[5] | 625, 454[5] | 100,000 | 1750 | 1050 | 875 |
| 1,000 | 1250, 952[5] | 750, 571[5] | 625, 476[5] | 150,000 | 1809 | 1085 | 904 |
| 1,500 | 1250, 1032[5] | 750, 619[5] | 625, 516[5] | 200,000 | 1849 | 1110 | 925 |
| 2,000 | 1250, 1087[5] | 750, 652[5] | 625, 544[5] | 250,000 | 1881 | 1128 | 940 |
| 2,500 | 1250, 1129[5] | 750, 678[5] | 625, 565[5] | 300,000 | 1905 | 1143 | 953 |
| 3,000 | 1250, 1164[5] | 750, 698[5] | 625, 582[5] | 350,000 | 1926 | 1156 | 963 |
| 3,500 | 1250, 1192[5] | 750, 715[5] | 625, 596[5] | 400,000 | 1944 | 1166 | 972 |
| 4,000 | 1250, 1217[5] | 750, 730[5] | 625, 608[5] | 450,000 | 1960 | 1176 | 980 |
| 5,000 | 1257 | 754 | 628 | 500,000 | 1974 | 1184 | 987 |
| 6,000 | 1290 | 774 | 645 | >500,000 | 2000 | 1200 | 1000 |

NOTES:

(1) $IBD = -678.3 + 273.9*(\ln(QDW))-5.47*(\ln(QDW))^2$
QDW in pounds, IBD in feet with a 656 feet minimum distance

(2) Use of equation to determine IBD ranges for other weights is allowed

(3) PTR = 60% of IBD

(4) ILD = 50% of IBD

(5) If the MCE for an item is known to be less than 100 pounds then the IBD equation given in Note (1) may be used and Notes (3) and (4) apply for PTR and ILD, respectively

# TABLE 5. PROPOSED HAZARD DIVISION 1.2 INTERMAGAZINE DISTANCES

**(note: all distances shown are in feet)**

| EXPOSED SITE (ES) | POTENTIAL EXPLOSION SITE (PES) | | | | | |
|---|---|---|---|---|---|---|
| | ECM[1] | | | HWB[2] | LWB[3] | LWBB[4] |
| | FRONT | SIDE | REAR | | | |
| **ECM (heavy)[5]--Front** | 82[b] | 7[a] | 7[a] | 33[a] | 82[b] | 33[a] |
| **ECM (heavy)[5]--Side** | 7[a] | 7[a] | 7[a] | 7[a] | 7[a] | 7[a] |
| **ECM (heavy)[5]--Rear** | 7[a] | 7[a] | 7[a] | 7[a] | 7[a] | 7[a] |
| **ECM (light)[6]--Front** | 164[a'] | 164[a'] | 164[a'] | 164[a'] | 164[a'] | 164[a'] |
| **ECM (light)[6]--Side** | 7[a] | 7[a] | 7[a] | 7[a] | 7[a] | 7[a] |
| **ECM (light)[6]--Rear** | 7[a] | 7[a] | 7[a] | 7[a] | 7[a] | 7[a] |
| **ECM[1]--barricaded--Front** | 82[b] | 7[a] | 7[a] | 33[a] | 82[b] | 33[a] |
| **HWBR[7]** | 33[a] | 7[a] | 7[a] | 33[a] | 33[a] | 33[a] |
| **HWB[2]** | 164[a'] | 164[a'] | 164[a'] | 164[a'] | 164[a'] | 164[a'] |
| **LWB[3]** | 164[a'] | 164[a'] | 164[a'] | 164[a'] | 164[a'] | 164[a'] |
| **LWBB[4]--Front** | 164[a'] | 164[a'] | 164[a'] | 164[a'] | 164[a'] | 164[a'] |

**NOTE 1: ECM is earth covered magazine**

**NOTE 2: HWB is building with walls ≥ 17.7 inches reinforced concrete (27.6 inches brick). HWB door is barricaded if it faces PES.**

**NOTE 3: LWB is light structure, open stack, truck, trailer, or railcar --unbarricaded**

**NOTE 4: LWBB is same structure as LWB with barricade**

**NOTE 5: ECM (heavy) is an earth covered magazine with a head wall thickness > 5.9 inches**

**NOTE 6: ECM (light) is an earth covered magazine with a head wall thickness < 5.9 inches**

**NOTE 7: HWBR is building with walls ≥ 17.7 inches reinforced concrete (27.6 inches brick) and roof >5.9 inches concrete. HWBR door is barricaded if it faces PES.**

**NOTE 8: Superscripts on distances represent the levels of protection shown below:**

a-level: There is virtually complete protection against immediate or subsequent fires and explosions caused by blast, flame, firebrands, projections and lobbed ammunition. The stocks are likely to be serviceable.

b-level: There is a high degree of protection against immediate propagation of explosion by blast, flame, and projections. There are occasional fires or subsequent explosions caused by firebrands, projections and lobbed ammunition. The extent of the loss of stocks at ES is determined by the effectiveness of the firefighting. If you increase b-level protection of 82 feet to 295 feet, a-level protection is obtained. If you increase b-level protection of 33 feet to 82 feet, a-level protection is obtained.

a'-level: 295 feet required for a-level protection.

ILD given in Tables 3 and 4 takes into account the progressive nature of explosions involving endangered areas before the progression involves large numbers of items. Exposed structures may be extensively damaged by projections and delayed propagation of explosions may occur due to the ignition of combustibles by projections. ILD is computed as 50% of the IBD for items of this hazard division.

When storing mixed Categories of HD 1.2 ammunition, the following rule shall apply. Use the total QDW and apply the distances for the higher Category. This is shown in Table 6.

**TABLE 6. HAZARD DIVISION 1.2 MIXING RULES**

| CATEGORIES INVOLVED | DISTANCES TO BE APPLIED |
|---|---|
| 1 | Apply Category 1 Distances |
| 2 | Apply Category 2 Distances |
| 1+2 | Apply Category 2 Distances |

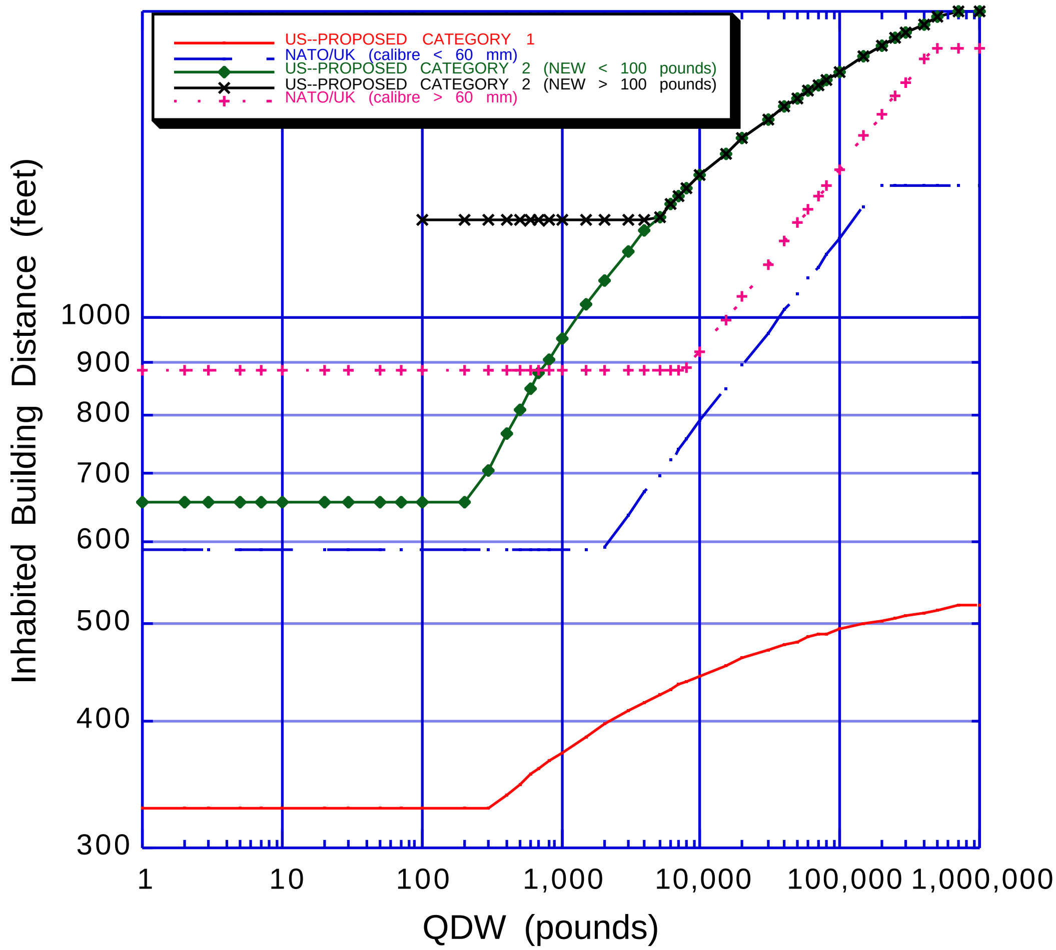
Figure 1 compares the proposed changes to the US criteria with the current NATO/UK criteria. The IBD for US Category 1 munitions is less than the NATO/UK category for items with calibre <60 mm for all explosive weights. For larger items, this is not the case. For many items in US Category 2, the proposed US changes will require greater Inhabited Building Distances than the NATO/UK criteria.

## ESTIMATED IMPACT OF PROPOSED CHANGES

A search of the United States Joint Hazard Classification System (JHCS) data base[10] has revealed that as of June 1996 there were 2,110 items that were hazard classified as HD 1.2. Table 7 shows how these HD 1.2 items were distributed. This table includes the kinds and numbers of items that could be affected by these proposed changes. Another way to estimate the impact of the changes is to look at their effect on selected ammunition items. These are shown in Tables 8 through 14. Each table gives a description of the item, the current US and NATO quantity-distance requirements and the new, proposed US requirement.

As expected, the new criteria present mixed results. That is, in some instances the new criteria would allow the storage of significantly more items with the same current hazard range. In other cases, significantly fewer items could be stored. This indicates that a transition period or rule should be developed to ease the change from the old rules to the new. Such a transition rule will be included with the final version of these changes.

**FIGURE 1. COMPARISON OF PROPOSED US AND NATO/UK CRITERIA**



## TABLE 7. HD 1.2 IBD DISTRIBUTION

| CURRENT U.S. INHABITED BUILDING DISTANCE (feet) | WEIGHT RANGE (pounds) | | TOTAL |
|---|---|---|---|
| | <0.30 | ≥0.30 | |
| 200 | 4 | 2 | **6** |
| 300 | 1 | 0 | **1** |
| 400 | 508 | 181 | **689** |
| 500 | 6 | 0 | **6** |
| 600 | 1 | 1 | **2** |
| 700 | 0 | 2 | **2** |
| 800 | 121 | 458 | **579** |
| 900 | 0 | 2 | **2** |
| 1000 | 0 | 2 | **2** |
| 1100 | 0 | 0 | **0** |
| 1200 | 87 | 701 | **788** |
| 1300 | 0 | 3 | **3** |
| 1400 | 0 | 0 | **0** |
| 1500 | 0 | 0 | **0** |
| 1600 | 0 | 0 | **0** |
| 1700 | 0 | 0 | **0** |
| 1800 | 0 | 30 | **30** |
| **TOTAL** | **728** | **1382** | **2110** |

## TABLE 8. 25 mm CARTRIDGE

| NUMBER OF ITEMS | QDW (lbs) | CURRENT US IBD (ft) | CURRENT NATO IBD (ft) | PROPOSED US IBD (ft) |
|---|---|---|---|---|
| 1 | 0.2324 | 400 | 591 | 328 |
| 5 | 1.162 | 400 | 591 | 328 |
| 10 | 2.324 | 400 | 591 | 328 |
| 20 | 4.648 | 400 | 591 | 328 |
| 50 | 11.62 | 400 | 591 | 328 |
| 100 | 23.24 | 400 | 591 | 328 |
| 200 | 46.48 | 400 | 591 | 328 |
| 500 | 116.2 | 400 | 591 | 328 |
| 1,000 | 232.4 | 400 | 591 | 328 |
| 1,500 | 348.6 | 400 | 591 | 333 |
| 2,000 | 464.8 | 400 | 591 | 344 |
| 5,000 | 1,162 | 400 | 591 | 378 |
| 10,000 | 2,324 | 400 | 609 | 401 |
| 20,000 | 4,648 | 400 | 690 | 422 |
| 50,000 | 11,620 | 400 | 813 | 447 |
| 100,000 | 23,240 | 400 | 921 | 464 |
| 200,000 | 46,480 | 400 | 1,044 | 478 |

| | |
|---|---|
| **DESCRIPTION** | CTG, 25 mm, APFSDS-T, M919, M261 CNTR |
| | |
| **DODIC** | A986 |
| **NEW/QD (lbs)** | 0.2324 |
| **US/IBD (ft)** | 400 |
| **HD 1.1 weight (lbs)** | 0 |
| **HD 1.3 weight (lbs)** | 0.2324 |

## TABLE 9. 40 mm Cartridge

| NUMBER OF ITEMS | QDW (lbs) | CURRENT US IBD (ft) | CURRENT NATO IBD (ft) | PROPOSED US IBD (ft) |
|---|---|---|---|---|
| 1 | 0.202 | 800 | 591 | 328 |
| 5 | 1.01 | 800 | 591 | 328 |
| 10 | 2.02 | 800 | 591 | 328 |
| 20 | 4.04 | 800 | 591 | 328 |
| 50 | 10.1 | 800 | 591 | 328 |
| 100 | 20.2 | 800 | 591 | 328 |
| 200 | 40.4 | 800 | 591 | 328 |
| 500 | 101 | 800 | 591 | 328 |
| 1,000 | 202 | 800 | 591 | 328 |
| 2,000 | 404 | 800 | 591 | 338 |
| 5,000 | 1,010 | 800 | 591 | 373 |
| 10,000 | 2,020 | 800 | 594 | 397 |
| 20,000 | 4,040 | 800 | 672 | 418 |
| 50,000 | 10,100 | 800 | 793 | 444 |
| 100,000 | 20,200 | 800 | 898 | 461 |
| 200,000 | 40,400 | 800 | 1,018 | 476 |
| 500,000 | 101,000 | 800 | 1,200 | 492 |

| | |
|---|---|
| **DESCRIPTION** | CTG, 40 mm, HEI-P-NP |
| | |
| **DODIC** | B556 |
| **NEW/QD (lbs)** | 0.2020 |
| **US/IBD (ft)** | 800 |
| **HD 1.1 weight (lbs)** | 0.2020 |
| **HD 1.3 weight (lbs)** | 0.007 |

## TABLE 10. Mine, AP, M16A2

| NUMBER OF ITEMS | QDW (lbs) | CURRENT US IBD (ft) | CURRENT NATO IBD (ft) | PROPOSED US IBD (ft) |
|---|---|---|---|---|
| 1 | 1.33552 | 800 | 886 | 656 |
| 5 | 6.6776 | 800 | 886 | 656 |
| 10 | 13.3552 | 800 | 886 | 656 |
| 20 | 26.7104 | 800 | 886 | 656 |
| 50 | 66.776 | 800 | 886 | 656 |
| 100 | 133.552 | 800 | 886 | 656 |
| 200 | 267.104 | 800 | 886 | 681 |
| 500 | 667.76 | 800 | 886 | 872 |
| 1,000 | 1335.52 | 800 | 886 | 1009 |
| 1,500 | 2003.28 | 800 | 886 | 1088 |
| 2,000 | 2671.04 | 800 | 886 | 1142 |
| 3,000 | 4006.56 | 800 | 886 | 1217 |
| 5,000 | 6,678 | 800 | 944 | 1309 |
| 10,000 | 13,355 | 800 | 1,070 | 1430 |
| 20,000 | 26,710 | 800 | 1,212 | 1545 |
| 50,000 | 66,776 | 800 | 1,429 | 1689 |
| 100,000 | 133,552 | 800 | 1,619 | 1792 |
| 200,000 | 267,104 | 800 | 1,834 | 1890 |

| | |
|---|---|
| **DESCRIPTION** | Mine, AP M16A2 W/M605 Fuze |
| | |
| **DODIC** | K092 |
| **NEW/QD (lbs)** | 1.33552 |
| **US/IBD (ft)** | 800 |
| **HD 1.1 weight (lbs)** | 1.33552 |
| **HD 1.3 weight (lbs)** | 0 |

## TABLE 11. 81 mm Mortar

| NUMBER OF ITEMS | QDW (lbs) | CURRENT US IBD (ft) | CURRENT NATO IBD (ft) | PROPOSED US IBD (ft) |
|---|---|---|---|---|
| 1 | 2.426 | 800 | 886 | 656 |
| 5 | 12.13 | 800 | 886 | 656 |
| 10 | 24.26 | 800 | 886 | 656 |
| 20 | 48.52 | 800 | 886 | 656 |
| 50 | 121.3 | 800 | 886 | 656 |
| 100 | 242.6 | 800 | 886 | 660 |
| 200 | 485.2 | 800 | 886 | 806 |
| 500 | 1213 | 800 | 886 | 990 |
| 1,000 | 2426 | 800 | 886 | 1124 |
| 1,500 | 3639 | 800 | 886 | 1199 |
| 2,000 | 4852 | 800 | 892 | 1252 |
| 5,000 | 12,130 | 800 | 1052 | 1413 |
| 10,000 | 24,260 | 800 | 1191 | 1529 |
| 20,000 | 48,520 | 800 | 1350 | 1640 |
| 50,000 | 121,300 | 800 | 1,592 | 1778 |
| 100,000 | 242,600 | 800 | 1,803 | 1876 |
| 200,000 | 485,200 | 800 | 1,837 | 1970 |
| 250,000 | 606,500 | 800 | 1,837 | 2000 |

| | |
|---|---|
| **DESCRIPTION** | CTG, 81 mm, HE, M374 W/O Fuze |
| | |
| **DODIC** | C236 |
| **NEW/QD (lbs)** | 2.426 |
| **US/IBD (ft)** | 800 |
| **HD 1.1 weight (lbs)** | 2.193 |
| **HD 1.3 weight (lbs)** | 0.233 |

## TABLE 12. Cartridge, M1, 105 mm

| NUMBER OF ITEMS | QDW (lbs) | CURRENT US IBD (ft) | CURRENT NATO IBD (ft) | PROPOSED US IBD (ft) |
|---|---|---|---|---|
| 1 | 5.08 | 1,200 | 886 | 656 |
| 5 | 25.4 | 1,200 | 886 | 656 |
| 10 | 50.8 | 1,200 | 886 | 656 |
| 20 | 101.6 | 1,200 | 886 | 656 |
| 50 | 254 | 1,200 | 886 | 670 |
| 100 | 508 | 1,200 | 886 | 815 |
| 200 | 1,016 | 1,200 | 886 | 955 |
| 500 | 2,540 | 1,200 | 886 | 1,132 |
| 1,000 | 5,080 | 1,200 | 899 | 1,260 |
| 1,500 | 7,620 | 1,200 | 967 | 1,332 |
| 2,000 | 10,160 | 1,200 | 1,018 | 1,383 |
| 5,000 | 25,400 | 1,200 | 1,201 | 1,537 |
| 10,000 | 50,800 | 1,200 | 1,361 | 1,647 |
| 20,000 | 101,600 | 1,200 | 1,542 | 1,752 |
| 50,000 | 254,000 | 1,200 | 1,818 | 1,883 |
| 70,000 | 355,600 | 1,200 | 1,837 | 1,928 |

| | |
|---|---|
| **DESCRIPTION** | CTG, 105 mm, M1 |
| | |
| **DODIC** | C445 |
| **NEW/QD (lbs)** | 5.08 |
| **US/IBD (ft)** | 1200 |
| **HD 1.1 weight (lbs)** | 5.08 |
| **HD 1.3 weight (lbs)** | 2.88 |

## TABLE 13. AGM-88A (HARM)

| NUMBER OF ITEMS | QDW (lbs) | CURRENT US IBD (ft) | CURRENT NATO IBD (ft) | PROPOSED US IBD (ft) |
|---|---|---|---|---|
| 1 | 46.4 | 400 | 886 | 656 |
| 2 | 92.8 | 400 | 886 | 656 |
| 5 | 232.1 | 400 | 886 | 656 |
| 7 | 325 | 400 | 886 | 722 |
| 10 | 464 | 400 | 886 | 797 |
| 15 | 696 | 400 | 886 | 880 |
| 20 | 928 | 400 | 886 | 937 |
| 50 | 2,321 | 400 | 886 | 1,115 |
| 70 | 3,249 | 400 | 886 | 1,178 |
| 100 | 4,641 | 400 | 886 | 1,244 |
| 150 | 6,962 | 400 | 951 | 1,316 |
| 200 | 9,283 | 400 | 1,002 | 1,367 |
| 500 | 23,207 | 400 | 1,182 | 1,522 |
| 700 | 32,490 | 400 | 1,256 | 1,576 |
| 1,000 | 46,414 | 400 | 1,339 | 1,633 |
| 1,500 | 69,622 | 400 | 1,440 | 1,695 |

| | |
|---|---|
| **DESCRIPTION** | G/M, AGM-88A |
| | |
| **DODIC** | PB24 |
| **NEW/QD (lbs)** | 46.4144 |
| **US/IBD (ft)** | 400 |
| **HD 1.1 weight (lbs)** | 46.4144 |
| **HD 1.3 weight (lbs)** | 327.414 |

## TABLE 14. Dispenser and Bomb, CBU-71A/B

| NUMBER OF ITEMS | QDW (lbs) | CURRENT US IBD (ft) | CURRENT NATO IBD (ft) | PROPOSED US IBD (ft) |
|---|---|---|---|---|
| 1 | 148 | 400 | 886 | 1,250 |
| 2 | 296 | 400 | 886 | 1,250 |
| 5 | 740 | 400 | 886 | 1,250 |
| 7 | 1,036 | 400 | 886 | 1,250 |
| 10 | 1,480 | 400 | 886 | 1,250 |
| 20 | 2,960 | 400 | 886 | 1,250 |
| 50 | 7,400 | 400 | 962 | 1,327 |
| 70 | 10,360 | 400 | 1,022 | 1,386 |
| 100 | 14,800 | 400 | 1,090 | 1,447 |
| 200 | 29,600 | 400 | 1,235 | 1,561 |
| 500 | 74,000 | 400 | 1,456 | 1,705 |
| 700 | 103,600 | 400 | 1,547 | 1,755 |
| 1,000 | 148,000 | 400 | 1,650 | 1,807 |
| 1,500 | 222,000 | 400 | 1,774 | 1,864 |
| 2,000 | 296,000 | 400 | 1,837 | 1,904 |
| 3,000 | 444,000 | 400 | 1,837 | 1,958 |

| | |
|---|---|
| **DESCRIPTION** | Dispenser and Bomb, CBU-71 A/B |
| | |
| **DODIC** | E828 |
| **NEW/QD (lbs)** | 148.0 |
| **US/IBD (ft)** | 400 |
| **HD 1.1 weight (lbs)** | 148.0 |
| **HD 1.3 weight (lbs)** | 0 |

## SUMMARY

Sufficient data have been developed in the open air portion of the HD 1.2 program to indicate the probable course for suggested rule changes. These changes will take a form quite similar to that currently used by NATO and the UK--namely, that the IBD depends on the explosive weight raised to some power or powers with both a minimum and maximum range. Further the definition of the energetic material weight to be used in these calculations is nearly identical with that used in NATO/UK.

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